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# EVALUATION AND COMPARISON OF ERTS MEASUREMENTS OF MAJOR CROPS AND SOIL ASSOCIATIONS FOR SELECTED SITES IN THE CENTRAL UNITED STATES

E73-11155) EVALUATION AND COMPARISON OF ERTS MEASUREMENTS OF MAJOR CROPS AND SOIL ASSOCIATIONS FOR SELECTED SITES IN THE CENTRAL UNITED STATES Progress (Purdue Univ.) 17 p HC $3.00 CSCL 08M G3/13 N73-33309 Unclas 01155

SIX MONTHS PROGRESS REPORT

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16. Abstract

Results of research performed at Purdue University during the second six months (1 January to 30 June, 1973) of the ERTS-1 Central States Contract are reported. ERTS-1 measurements over six test sites were received. Within the Lubbock Regional Test Site, analysis of three sets of temporally overlayed data (9 October, 1972; 14 November, 1972; 2 December, 1972) from Lynn County, Texas indicated that changes in the surface water area of Tahoka Lake could be determined Soil association mapping was also done in Lynn County, using photo-interpretive techniques of analysis on single bands of MSS data. Ground observations for the Lubbock Regional Test Site will be collected during the 1973 growing season, and have already been received for two ERTS passes, 20 March and 18 June. Urban land use was mapped in the Kansas City metropolitan area. Spectrally separable classes developed were commerce/industry, older housing, newer housing, wooded residential, water, and agricultural areas.

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# I. PREFACE

## A. Objectives.

The objectives of the research reported herein are outlined in the Data Analysis Plan for the Investigation "Evaluation and Comparison of ERTS Measurements of Major Crops and Soil Associations for Selected Sites in the Central United States," ERTS-1 Proposal Number SR050. The broad objective of the proposal is to evaluate the utility of ERTS-1 measurements for use in identifying, locating, characterizing and mapping differences in vegetation and soils over a wide range of climatic, geographical, and ecological conditions in the Central United States.

## B. Scope of Work.

ERTS-1 measurements are being obtained over six widely separated test sites, These include (1) Boone and Hendricks Counties, Indiana, (2) Wells County, North Dakota, (3) Humboldt County, Iowa, (4) McPherson County, Nebraska, (5) Greeley County, Kansas, and (6) a 10-county area centering around Lubbock, Texas. Fifty-six ground observation sites, each of approximately 10 kilometers in length, have been designated for the Lubbock Regional Test Site. Observations of agricultural significance have been collected on the ERTS overpass dates of 20 March, 13 May, 31 May, and 18 June. They will be continued during the 1973 growing season. Digital computer techniques (the LARS software system) are being used in the analysis of all ERTS-1 data.

## C. Conclusions.

This is an interim progress report and no final conclusions on the study seem to be appropriate at this time. Significant results in the delineation and mapping of soils and other earth surface features are described herein. Research in the next six months should provide significant results in the identification and mapping of crop species under both irrigation and dryland conditions.

## D. Summary of Recommendations.

It is recommended that the time lag between coverage and receipt of images and CCT data be reduced if possible so that data quality may be evaluated and ground observations made sooner if data are considered acceptable.

## TABLE OF CONTENTS

## II. STATUS OF ERTS DATA
## 1 January 1973 - 30 June 1973

During this reporting period CCT's were received for 179 frames of ERTS data over the six test sites of this project. Data have been received which covers all or parts of each of the six test sites of the investigation. Many of the passes during the winter occurred at times when the ground was covered by snow, making identification of surface features impossible. Seventy-eight of the frames were judged to be of no use for investigative purposes because of cloud cover. One list of data tapes returned is included (Table 1) and another list has been compiled and will be included in the next reporting period.

Several data tapes have had six line noise in one or more of the channels. Among those with one bad channel are scenes 1044-16595, band 4; 1061-16564, band 5; 1006-16522, band 5; and 1057-16323, bands 4 and 6.

## III. URBAN LAND USE ANALYSIS IN KANSAS CITY, MISSOURI-KANSAS BY COMPUTER PROCESSING OF ERTS MSS DATA

### A. Introduction

The acquisition and monitoring of land use in large metropolitan araas is an essential task in urban and regional planning. Planners must have timely and accurate data to make good decisions regarding land use. One such data source is NASA's Earth Resources Technology Satellite, launched in July of 1972. The satellite can collect data over any given city every eighteen days, weather permitting.

On August 13, 1972 a frame of data collected by the satellite was cloudless over a large area in Kansas and Missouri (Observation ID 102116333). The Kansas City, Missouri-Kansas, subframe (Figure 1) was chosen for the land use analysis. The subframe includes all or part of seven counties--Clay, Jackson, and Cass Counties, Missouri, and Platte, Wyandotte, Johnson, and Leavenworth Counties, Kansas. Four bands of digitized multispectral sensor data were used in the study.

### B. Procedure

The four bands of data (two of which are shown as Figures 1-A and B) were initially viewed on a digital imaging display. At that time, three functions were performed. The first step involved determining the areal extent of the study area. Moreover, a number of dominant areal features were identified and their line/column coordinates recorded, to aid in interpretation of line printer maps, such as rivers, airports, highways, parks, and reservoirs. Secondly, several areas were chosen for the histogramming

Table 1. Unusable Data Tapes Returned to GSFC Because of Cloud Cover.

| | | |
|---|---|---|
| 1080-17014 | 1130-16390 | 1168-16533 |
| 1051-15591 | 1134-17022 | 1149-16482 |
| 1094-16420 | 1134-17031 | 1168-16535 |
| 1043-16575 | 1130-16422 | 1166-16420 |
| 1080-17000 | 1151-16563 | 1168-16524 |
| 1095-16472 | 1149-16480 | 1168-16530 |
| 1095-16465 | 1148-16422 | 1168-16541 |
| 1096-16524 | 1167-16481 | 1169-16573 |
| 1095-16481 | 1178-16045 | 1186-16524 |
| 1095-16474 | 1167-16472 | 1186-16533 |
| 1094-16422 | 1167-16474 | 1170-17043 |
| 1043-16582 | 1152-17030 | 1188-17041 |
| 1096-16533 | 1167-16465 | 1203-16483 |
| 1097-16591 | 1152-17003 | 1203-16474 |
| 1096-16535 | 1170-17045 | 1203-16481 |
| 1097-16585 | 1166-16423 | 1206-17005 |
| 1097-16594 | 1169-16582 | 1206-17023 |
| 1105-15593 | 1169-16584 | 1206-17050 |
| 1113-16464 | 1169-16593 | 1205-16585 |
| 1114-16541 | 1134-17022 | 1205-17000 |
| 1116-17031 | 1169-16570 | |
| 1115-16593 | 1169-16591 | |
| 1116-17033 | 1150-16534 | |
| 1115-16590 | 1170-17040 | |
| 1115-16584 | 1186-16540 | |
| 1123-15594 | 1186-16531 | |
| 1123-16000 | 1187-16544 | |
| 1133-16584 | 1185-16475 | |

processor for future, more controlled viewing on the digital display. Finally, several small areas were chosen for a clustering processor, taking care to obtain a representative sampling of the spectral variability in areas.

Fourteen spectral classes were requested of the clustering program. The statistics from these cluster classes were used to classify all of the data points in the study area, and the results were displayed by a line printer using different alpha-numeric symbols for each class. The resulting cluster map was used as a base map, in conjunction with ground truth, on which small, rectangular samples of each desired spectral class could be located. Statistics from these classes were used to classify the study area again. Eight classes were used--older housing, newer housing, wooded residential, commerce/industry, river water, reservoir water, agricultural areas (bright infrared reflectance), and agricultural areas (dark infrared reflectance). Gray levels used in photographing the results from the digital display (Figure 1-C) area as follows:

| | |
|---|---|
| Commerce/industry | - medium gray |
| Older housing | - black |
| Newer housing | - white |
| Wooded residential | - light gray |
| Agricultural areas | - dark gray |
| Reservoir water | - black |
| River water | - very dark gray |

Two of the classes--older housing and reservoir water--have been displayed as black, but their areal distribution should not be confusing. There exists approximately eight small reservoirs and ponds in the classification image, all of which are located peripheral to the urbanized (built-up) area. Older housing is confined to the right-center of the image, in the middle of the urbanized area.

Care must be taken in the viewing/analysis of the three Kansas City images, because the vertical and horizontal scales are different. The disparity is a result of the digital display unit; the true ratio of length to width of a data point is 4:3, while the digital display shows the data in the ration of 1:1. The east-west scale of the imagery is approximately 1:533,000, while the north-south scale is approximately 1:663,000.

C. Results

No quantititive assessment of the accuracy of the Kansas City classification will be reported at this time, because the ground truth either has not been fully acquired or has not been fully coordinated/correlated with the ERTS data. Valuable assistance in the acquisition of ground truth is being given by representatives of the Cooperative Extension Service (U.S. Department of Agriculture, University of Missouri - Extension Division). Evaluation of limited ground truth, nevertheless, allows qualitative remarks concerning the accuracy of classification to be made.

The spectral class commerce/industry is found primarily in the center of the urbanized area, near the confluence of the Missouri and Kansas Rivers, and primarily in four municipalities--Kansas City, Kansas; Kansas City Missouri; North Kansas City, Missouri; and Independence, Missouri. Rooftops and concrete are the two primary constituents of this spectral class.

Areas of older housing are found in the same four municipalities as commerce/industry, surrounding the latter class. Population density is relatively high in these areas, owing to the close spacing of structures and the multi-family characteristic of occupance. Mature vegetation (trees) and rooftops are the dominant land cover types of this class.

Wooded residential areas are older, upper income areas. A single, large area is found approximately four miles southwest of the Central Business District of Kansas City, Missouri. The area includes the municipalities of Fairway, Mission Hills, Prairie Village, all in Kansas, along with the residential area in Kansas City, Missouri known as Country Club. Green vegetation, as well as rooftops, is the dominant areal feature of this class.

Areas of newer housing surround the three classes described above. Single-family residences built on moderately-sized lots are the characteristic land use. Lawns (grass) and roads (concrete) are probably the two main constituents contributing to the spectral nature of this class. Not unusually, therefore, interstate highways and other main roads were classified as newer housing.

The distribution of water was limited to reservoirs, lakes, ponds, and rivers. The two types of water--reservoir water and river water--were easily separated because of the variation in the visible bands. Reasons for the water differences are most likely related to silt load and pollution. A problem arose in the classification of the Kansas River near its confluence with the Missouri. Data points were frequently confused with commerce/industry, owing to the ten bridges which span the river in that small distance.

Agricultural areas, located around the perimeter of the classification image, presented the greatest difficulty in classification. Many data points in those areas were misclassified as newer housing. Green vegetation, of course, is the principal component of the agricultural classes. Usually, urban earth surface features such as parks, golf courses, and cemeteries were also classified into this spectral category.

D. Conclusions

It is believed that the results of this investigation warrant serious consideration by urban-regional planners of the possibilities of computer processing of ERTS MSS data. Urban land use was mapped with good accuracy and the problems encountered were minimal, i.e., can be solved by further research.

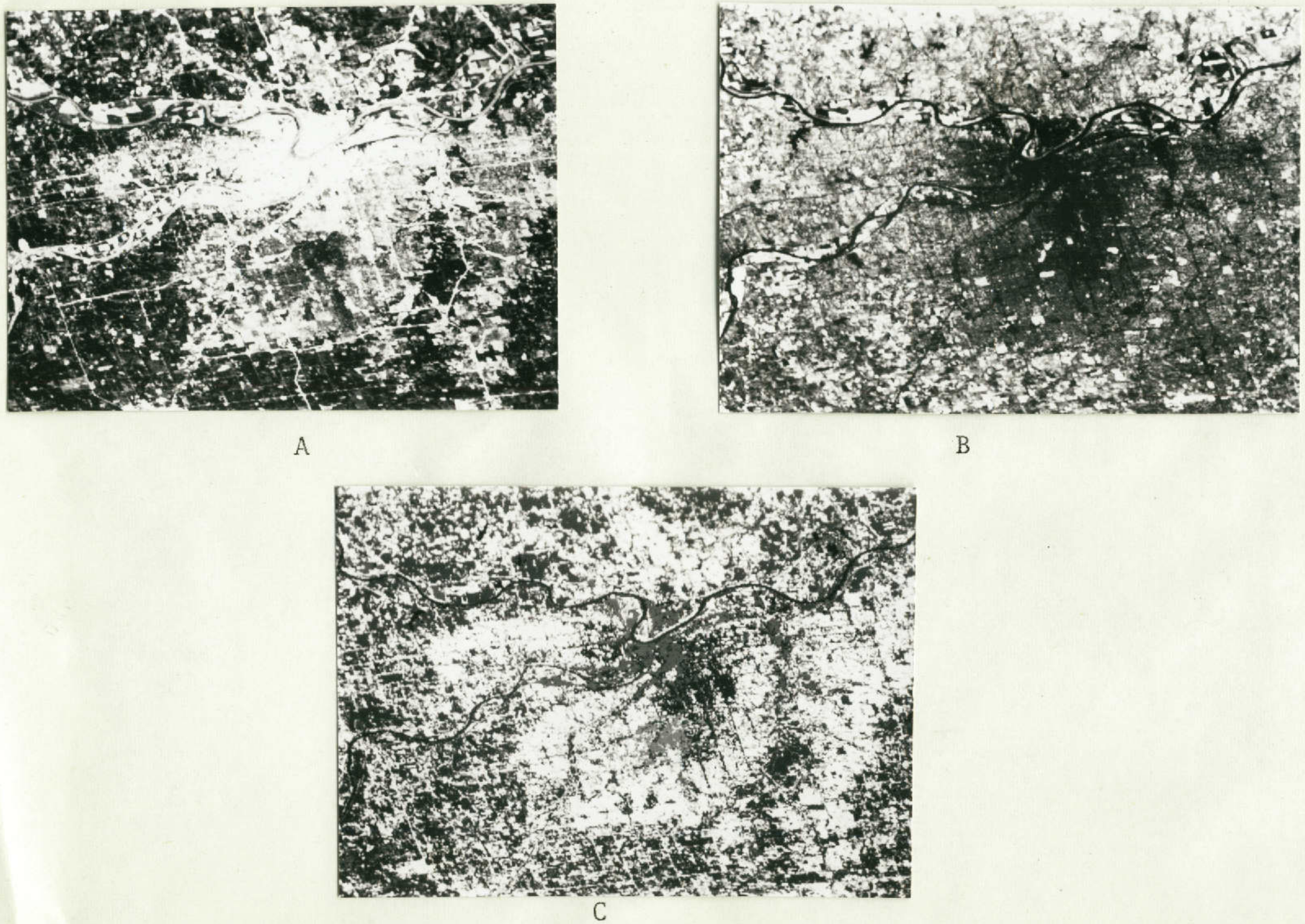


Figure 1. Photos of Kansas City area from digital display. Image in A from the visible portion of the spectrum (Band 5, 0.6-0.7 m); B is from the reflective infrared (Band 7, 0.8-1.1 m). Image in C is the land use classification using all four bands (see text for explanation of gray levels).

# IV. ANALYSIS OF ERTS-1 DATA FROM THE LUBBOCK REGIONAL TEST SITE

## A. Detecting Changes in Water Quality and Surface Area in Tahoka Lake, Lynn County, Texas.

ERTS-1 Scene ID Numbers:

| | |
|---|---|
| E-1078-16524 | 9 October 1972 |
| E-1114-16532 | 14 November 1972 |
| E-1132-16532 | 2 December 1972 |

ERTS MSS data from three passes over Lynn County, Texas were temporally overlayed, i.e., spatial resolution of data from three ERTS passes on a point by point basis. Resolution of the resulting data was not significantly reduced because the overlayed points were within one-half of a resolution element of the base data. A non-supervised classification was made of Tahoka Lake using the infrared bands (MSS 6 and 7) for the three overlayed dates.

Classes from the non-supervised classification are normally based entirely on spectral data, but because the data used in the above classification were from three dates, classes were based on both spectral and temporal differences. It was found that there were four major types of classes: (1) classes which were not water on any of the three days, (2) classes which were water for all three days, (3) classes which were water on only two days, and (4) classes which were water on only one day. By analyzing the arrangement of these points, changes in water surface area can be observed. Deep and/or clear water can be distinguished from shallow and/or turbid water by comparing the class means provided by the classification.

## B. Multispectral Data as a Tool in Identifying and Mapping Soil Associations of Lynn County, Texas

ERTS-1 Scene I.D.

| | |
|---|---|
| E-1132-16532 | 2 December 1973 |

Multispectral reflectance data were obtained over Lynn County, Texas on 2 December 1972. This county was selected for this study because of the range in soil conditions and the availability of a modern soil survey report to aid in the evaluation of ERTS data.

The objective of this study was to examine black and white images of each of the four MSS bands of data and evaluate each of the bands for their utility in preparing a soil association map of Lynn County. Photointerpretation techniques were used to analyze and compare the images of each of the four bands of MSS data.

Initially the most conspicuous and readily identifiable cultural and soil features were examined and comparisons made between individual features in each of the four bands. Water, rangeland boundaries, and rough broken land were the most conspicuous and easily separable features. Major highways, railways where they adjoined highways, drainage patterns, playas, and the more distinctive soil associations were easily identified with varying degrees of completeness and accuracy. However, there were marked differences in the clarity of the ERTS MSS bands. Ranked from most to least useful were bands 7, 4, 6, and 5. The contrast in the range from light to dark gray in bands 6 and 5 was too great to distinguish more than the water and range land boundaries. Band 4 was used to supplement band 7 in a few areas where it was difficult to distinguish (1) drainage-ways and rough broken land in a rangeland area in the southeastern corner of the county, and (2) playas and the slightly sloping and eroded, lighter colored soils surrounding the depressions from the darker colored soils of the divides. This latter distinction was particularly difficult in the northwestern corner of the county.

As the interpreter was unfamiliar with the Lynn County area, it was necessary to consult maps and reports to visualize the physiography, topography, geology, land use, and cultural features of the region. The Soil Survey Report of Lynn County was studied to determine the external and internal characteristics of the soils and their classification and to make predictions as to their separability by interpreting ERTS imagery.

The water and miscellaneous land types, cultural features, and soils were tabulated and arranged in the order in which they were expected to be interpretable. After the preparation of this array, the lakes were identified and delineated; sloping and rough broken land surrounding the deep set lakes was delineated, and stream dissection that was identifiable was mapped. In this setting it was then possible to identify certain playas and the relation of the soils to the topography. North-south extending lakes such as Tahoka Lake were used to determine the north-south scale. The east-west distance between lakes such as Mound, Double, and Tahoka were used to establish the east-west scale.

The interpreter then worked westward trom Tahoka Lake to Mound Lake, identifying the various features and delineating them as lakes, playas, and land use lines. In this way it was possible to locate the western county line at Mound Lake and then work counter clockwise around the county boundary. The southeast corner of the county was located with respect to the intermittant drainage and the rough broken land surrounding Moores Canyon along the Brazos River. Some features such as Patter soils were not recognizable or separable on ERTS imagery, but could be related generally to other features such as permanent pastures or rangelands.

Only fragments of major highways were identifiable, and these were used and projected through the county as a means of separating the surrounding soils. The dark colored soils, classified as Mollisols, were most difficult to identify in the northern fifth of the county where the imagery was especially dark, lacking in contrast, and the area was known to have numerous playas interspersed through it. The playas were so numerous that it was difficult to identify key ones for landscape interpretation. Playas were commonly surrounded by light colored areas (highly reflective in bands 4 and 5) or rings of light colored soils which normally indicates erosion. In this case it is believed possible that the soils may be too lightly colored to be classified as Mollisols.

In certain areas around East and West Double Lakes there is a mixture of light and dark colored patterns which reflect the intricate and inseparable mixture of light and dark soils. In such areas it was essentially impossible to eatablish soil boundaries by visual interpretation of ERTS imagery. Among the dark colored soils, it was exceedingly difficult to detect significant image differences by which they could be delineated.

In concluding this study of visual interpretation of ERTS multispectral imagery for mapping soils, it should be emphasized that the interpretation and identification of different soils would have been essentially impossible without the aid of a relatively recent soil survey report. The quality and limitations of the map produced from ERTS imagery should be evaluated by field examination.

ERTS multispectral data are being used in a study of the soils of Lubbock, Lamb and Crosby counties. In the case of these areas both machine-processing and photointerpretation techniques are being employed. Results from these studies will be presented in forthcoming reports.

C. Ground Observation Collection System

Ground observations are now being made for the 1973 growing season. Observations are being made for each ERTS pass by a system of volunteer observers. This system is described in more detail in the semi-annual report covering the period July to December 1972 submitted for this project.

Ground observations have been received for two clear ERTS pass dates (1) 20 March and (2) 18 June. A summary of the response per county and the response per target county is presented below. The overall response from the volunteer ground observers in all nine counties was slightly less than expected, but from the three target counties, Hale, Lubbock, and Lynn, response was very good.

| County | Ground Observers | % Reported (two passes) |
|---|---|---|
| Crosby | 5 | 30 |
| Dawson | 5 | 40 |
| Floyd | 3 | 33 |
| Garza | 5 | 50 |
| Hale | 5 | 90 |
| Hockley | 3 | 0 |
| Lamb | 4 | 63 |
| Lubbock | 7 | 71 |
| Lynn | 6 | 58 |
| Total | 43 | 52 |

| Target Counties | Ground Observers | % Reported |
|---|---|---|
| Hale | 5 | 90 |
| Lubbock | 7 | 71 |
| Lynn | 6 | 58 |
| Total | 18 | 72 |

In addition to the regular system of ground observations described above which will accompany each ERTS pass, a ground observation mission will be carried out by two members of the LARS staff for the 6 July 1973 ERTS pass. Observations will be confined to three counties (Hale, Lubbock, and Lynn) and will be made in two ways: (1) completing ground observation forms for selected fields, and (2) taking low altitude photos of the selected fields. Three North-South transects across Hale, Lubbock, and Lynn County were chosen for making ground observations. Detailed observations will be made at road intersections. These intersections are at an interval of 2 to 4 miles to give a well distributed set of ground observations covering the three counties. At each intersection, observations will be recorded for 4 fields. The second phase of the ground observation mission will be a low altitude flight over the selected intersections and other areas of interest. The photos taken during this flight along with the detailed ground observations will provide the researcher with an accurate representation of the crop and soil conditions at the time of the 6 July 1973 ERTS pass.

D. Analysis of ERTS Data from Texas and New Mexico

| NASA Scene I.D. | Date of Pass | LARS Run Number |
|---|---|---|
| 1132-16532 | 2 Dec. 1972 | 72056800 |
| 1132-16541 | 2 Dec. 1972 | 72056700 |
| 1133-16591 | 3 Dec. 1972 | 72051800 |
| 1133-17000 | 3 Dec. 1972 | 72056400 |
| 1134-17052 | 4 Dec. 1972 | 72056200 |
| 1153-17105 | 23 Dec. 1972 | 72063700 |

A survey of the utility of Remote Sensing data in general and ERTS MSS data in particular was made and presented at the

AAAS-CONACYT meeting in Mexico City. The paper emphasized the use of ERTS imagery to map and monitor arid and semi-arid lands. Major features of interest which can be identified easily on ERTS imagery include: (1) surface water, (2) agricultural areas, (3) urban and built-up areas, and (4) geologic features.

Several methods of analysis are available to organizations depending on their resources: (1) photo interpretation of black and white photography, (2) photo interpretation of color enhanced photography, and (3) computer analysis of MSS data. Some useful analysis can be done on black and white enlargements using conventional photointerpretation techniques. In this type of analysis general soil, geologic and some land use patterns may be distinguished. In areas of high relief limited stereo coverage may be obtained from the sidelap and overlap of the ERTS scenes. Useful information may also be obtained by using conventional photointerpretation on color enhanced photography because three MSS channels are used (generally 4, 5 and 7). The two analysis techniques briefly described above may be useful as the primary method of analysis to organizations which are just beginning to use ERTS data or have limited resources.

Computer analysis of ERTS MSS data, using a processing system similar to LARSYS, appears to be the best method of analysis for obtaining certain types of information from the scanner data. If training areas are properly chosen, information concerning the agriculture, land cover (land use), soils, and, to a lesser extent geology, may be rapidly and accurately determined for an area.

# ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

DATE August 1973

PRINCIPAL INVESTIGATOR Baumgardner, M. F. ← PLEASE FILL IN

GSFC UN 630

ORGANIZATION Laboratory for Applications of Remote Sensing

NDPF USE ONLY
D ______
N ______
ID ______

| PRODUCT ID (INCLUDE BAND AND PRODUCT) | FREQUENTLY USED DESCRIPTORS* urban | agric. | water | DESCRIPTORS |
|---|---|---|---|---|
| 1078-16524 | x | x | x | Playa<br>Cotton - irrigated and dry |
| 1078-16522 | x | x | x | Ecarpment<br>Fluviatile Plain |
| 1114-16534 | | x | | Clouds, Sand Dunes<br>Oil Field |
| 1114-16532 | x | x | x | Playa, Escarpment |
| 1114-16541 | | | | Anticline, River Bed<br>Fault |
| 1132-16530 | x | x | x | Escarpment, Playa |
| 1133-16591 | x | x | | Rangeland, Oil Field |
| 1132-16532 | x | x | x | Escarpment, Playa |
| 1132-16541 | | | | Anticline, River<br>Fault |
| 1133-17000 | x | x | x | Igneous Rocks, Fault |
| 1133-16593 | x | x | x | River,Sand Dunes |
| 1024-16525 | x | x | x | Playa,Escarpment |
| 1006-16522 | x | x | x | Playa, Escarpment |
| 1024-16522 | x | x | x | Playa, Escarpment |
| 1069-15585 | x | x | | Corn, Pasture, Soil |
| 1177-15593 | x | x | x | Ground Moraine |
| 1044-16595 | | x | x | River, Ablation Moraine, Ground Moraine, Lake Bed |

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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| PRODUCT ID (INCLUDE BAND AND PRODUCT) | FREQUENTLY USED DESCRIPTORS* | | | DESCRIPTORS |
|---|---|---|---|---|
| | Urban | Agric. | Water | |
| 1057-16323 | | x | x | Soils, Lake |
| 1061-16564 | | x | x | Soil |
| 1007-16563 | | x | x | Soil |

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